Chapter 3

National Missile Defense

Chapter 3
National Missile Defense (NMD)

3.1 Introduction

The Department of Defense (DoD) is working to develop a National Missile Defense (NMD) capability to defend the United States from an emerging Rest-of-World (ROW) rogue state ballistic missile threat or against a limited accidental or unauthorized missile launch. Toward this end, DoD established the NMD Deployment Readiness Program, which positions the United States to respond to a threat as it emerges.

In early 1996, DoD completed a comprehensive review of its Ballistic Missile Defense Program, followed by a decision to shift the NMD Program from a technology to a deployment readiness program. Current program strategy is based on the “3+3” concept -- a three year development and planning phase, that, if necessary, could be followed by a three year system development and deployment phase. DoD is fully committed to the first phase of the “3+3” NMD program. In response to the shift from technology to deployment readiness, the Undersecretary of Defense for Acquisition and Technology (USD(A&T)) designated NMD as an Acquisition Category-ID (ACAT-ID) Major Defense Acquisition Program (MDAP).

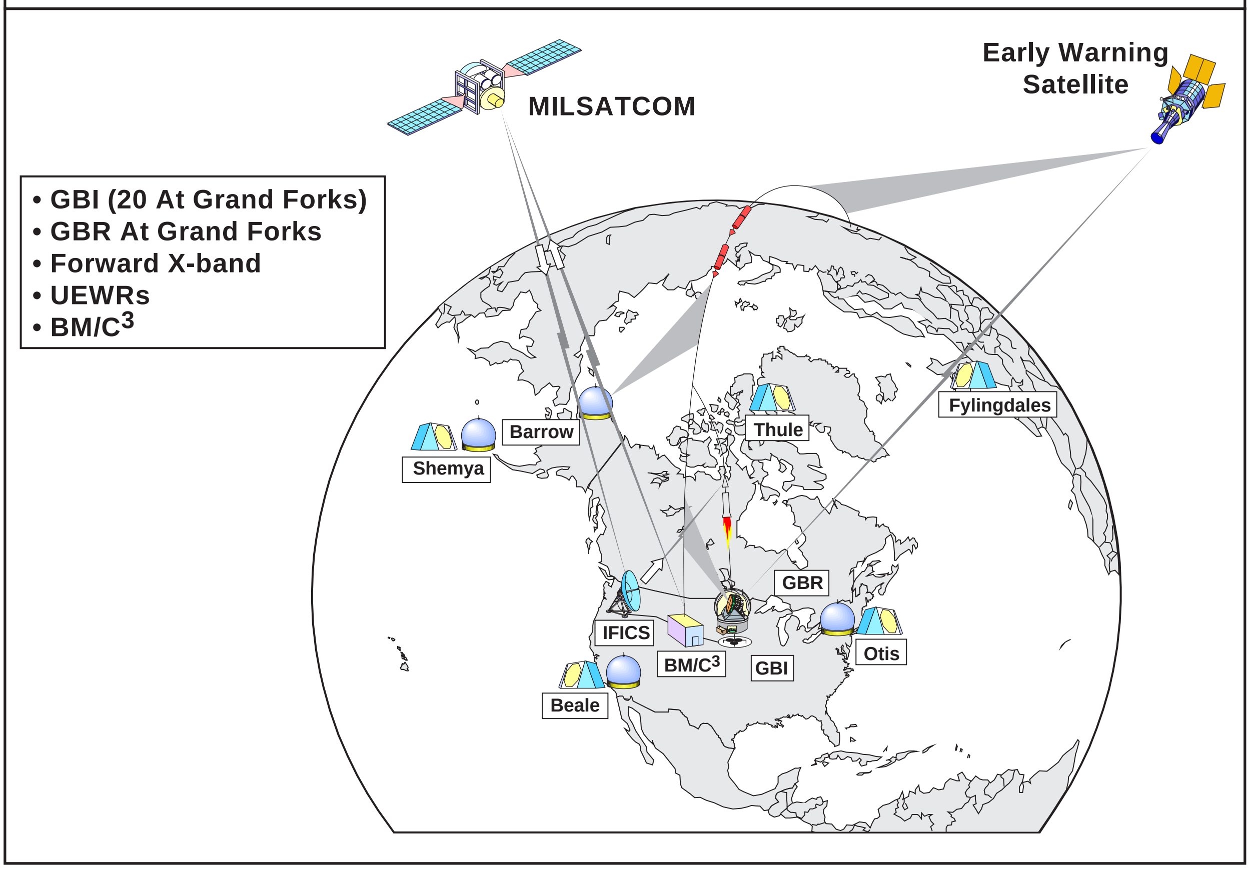
NMD funding changed based on Congressional direction and DoD’s NMD program strategy, which will permit the completion of a development program leading to the demonstration of the NMD system in an Integrated System Test (IST) in FY 1999. Funding shifted forward in the Future Year Defense Program (FYDP) with allocations of approximately an additional $100 million per year in FY 1997-1998. Congressional funding increases provided $375 million in FY 1996 and $325 million in FY 1997 for NMD above DoD’s request.

During the initial development phase of the NMD “3+3” Program, subsystem elements will be integrated into a limited capability system, culminating with an Integrated System Test (IST) in FY 1999. A decision to deploy could be made as soon as 2000 based on a successful demonstration of system capability and validation of a ballistic missile threat. If the threat and program progress warrant a decision to deploy, then an Initial Operational Capability, designated as Capability 1, could be deployed as early as 2003. However, if a deployment decision is deferred, the program will continue improving the NMD deployment readiness posture by advancing the technology of each element while maintaining the capability to deploy the system within three years of a decision--ultimately leading to the development of an objective system capable of defending against more sophisticated threats, designated as Capability 2. The Department’s goal is to achieve an NMD deployment readiness posture that ensures deployment is at most three years away from a decision to deploy. Given the uncertain timing of the threat, the specific scenario in which a threat may emerge, and the length of time required to deploy a system to defend against these threats, the NMD Deployment Readiness “3+3” strategy accommodates the uncertainty of the threat to the United States while allowing an orderly evolution of capability as the technology matures.

3.1.1 System Concept

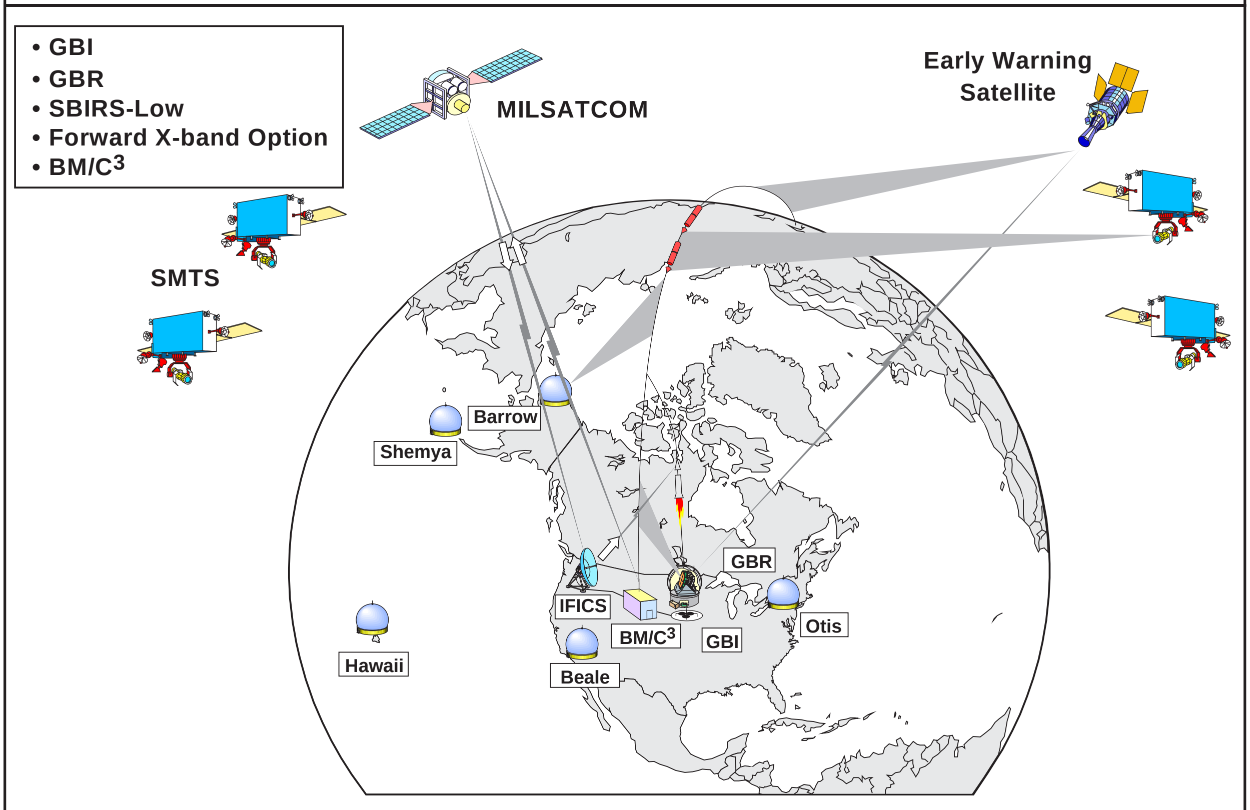
If deployment of an NMD system is mandated soon after the FY 1999 IST, an initial architecture could be in place by 2003. That architecture would consist of the following basic elements integrated as a system: (1) a Ground Based Interceptor (GBI) element capable of receiving and processing in-flight target updates, performing onboard target selection, and providing reliable target destruction; (2) a Ground Based Radar (GBR) to act as the primary fire control sensor; (3) an Upgraded Early Warning Radar (UEWR) and other Forward-Based X-band Radars (FBXRs) as required; (4) early warning satellites to detect a ballistic missile launch (i.e., the Defense Support Program (DSP) satellite or Space Based Infrared System (SBIRS)-High); and (5) a Battle Management/Command, Control, and Communications (BM/C^3) element for system integration, informed decision making by humans in control, and engagement planning and execution. The Capability 1 architecture, depicted in Figure 3-1, will meet the threshold values of the user's operational requirements as established in the Joint Requirements Oversight Council (JROC)-validated National Ballistic Missile Defense (BMD) Capstone Requirements Document (CRD) and Joint Operational Requirements Document (ORD), and will provide high levels of operational effectiveness against a limited threat comprising a few simple reentry vehicles from a ROW country.

Figure 3-1. Capability 1 NMD Architecture



If the deployment of an NMD system is deferred, the NMD "3+3" Program will continue to improve the deployable defense system as element technologies advance and new elements are introduced until the objective system architecture, Capability 2, is attained. Such an architecture would add a constellation of SBIRS-Low space-based sensors to the above-mentioned subsystem elements and would specify sensor and interceptor ground sites that are designated to deal with a specific threat. A representative architecture that could be deployed and would meet the objective system requirement of providing a high level of protection against a modest number of more complex threats is depicted in Figure 3-2.

Figure 3-2. Capability 2 NMD Architecture



3.2 Threat

3.2.1 National Intelligence Estimate

A National Intelligence Estimate on the emerging missile threats to North America during the next 15 years was issued, representing the views of the Director of Central Intelligence with the advice and assistance of the U.S. Intelligence Community. The Defense Intelligence Agency (DIA)-validated Strategic Threat Assessment (STA) contains the DIA-validated threats which the NMD system is designed to counter.

The intelligence community has concluded that no country, other than the major declared nuclear powers, will develop or otherwise acquire a ballistic missile in the next 15 years that could threaten the contiguous 48 states; only a North Korean missile in development, the Taepo Dong 2, could conceivably have sufficient range to strike portions of Alaska or the far-western Hawaiian Islands, but the likelihood of it being operational within five years is very low.

The threat from an accidental or unauthorized launch from the former Soviet Union or China is assessed to be remote. The number of former Soviet Union strategic ballistic missiles, the number of bases and submarines from which they could be launched and the number of countries where they are based are being reduced by the Strategic Arms Reduction Treaty (START) and the Cooperative Threat Reduction (CTR) program. In addition, a ballistic missile detargeted according to the 1994 Clinton-Yeltsin agreement, in the highly unlikely event it were launched accidentally, would land in the ocean.

3.2.2 Design to Threat

The design-to-threat is categorized with the labels System Threat-1 (ST-1) through ST-4, representing the increasing sophistication and quantity of future threats. ST-1 includes up to four rudimentary first generation warheads. ST-2 includes up to four warheads with little sophistication beyond a rudimentary ascent shroud in order to present a “cold” target in the midcourse phase of the warhead trajectory, and includes no jammers or penaids. ST-1 and ST-2 are typical of the type that could be expected through indigenous development efforts in ROW countries such as North Korea, Iraq, or India. ST-3 includes up to four warheads of more sophisticated design, and could include simple jammers or penaids, or a higher yield nuclear warhead. This would be typical of a portion of the threat from an accidental or unauthorized launch from Russia or China or an authorized launch from an ROW country after it has obtained more sophisticated technology through proliferation. ST-4 includes up to 20 warheads of complex design, including advanced responsive jammers, and penetration aids, or a Multiple Independently-targetable Reentry Vehicle (MIRV) weapon.

3.3 Requirements

The National BMD CRD and the Concept of Operations (CONOPS) for Ballistic Missile Defense of North America represent the approved baseline requirements documentation for the NMD Program. Together, they form the basis for developing the NMD Joint ORD, validated by the JROC in March 1997. DoD Order 5000.2-R and MOP 77 allow the NMD Joint ORD to become the primary driver of the NMD system requirements.

3.3.1 National Ballistic Missile Defense (BMD) Capstone Requirements Document and NMD Joint Operational Requirements Document (ORD)

The National BMD CRD contains the United States Space Command’s (USSPACECOM) top-level operational requirements that will be used as the framework to develop the NMD system. The NMD CRD, validated August 24, 1996, supersedes the December 1994 Capstone ORD for BMD to address only National BMD needs. The NMD Joint ORD, approved in March 1997, has the same key performance parameters as the CRD. The key performance parameters identified in the Joint ORD establish the minimum capabilities needed to perform its mission of defending the United States from limited ballistic missile attacks. The Joint ORD defines threshold and objective standards for the operational effectiveness an NMD system capability based on assured human-in-control and automated BM/C^3 decision support systems. The Joint ORD forms the basis for developing the BMDO NMD System Requirements Document (SRD), which establishes the development program baseline for the NMD system architecture, system performance and interface requirements, and element performance requirements. From this baseline system, additional capabilities could be added to defend against the objective threat as future changes dictate.

3.3.2 Concept of Operations (CONOPS) for Ballistic Missile Defense of North America

The CONOPS for BMD of North America, validated by the Commander-in-Chief, U.S. Space Command (USCINCSPACE), establishes the operational guidance on the manner in which USSPACECOM plans to operate and employ the National Missile Defense capability. The CONOPS establishes the user's intentions for centralized control of NMD with decentralized execution through Service components. The CONOPS also specifies the procedures to ensure the development of an operationally suitable and effective NMD system, which enables detailed development of the BM/C^3 architecture.

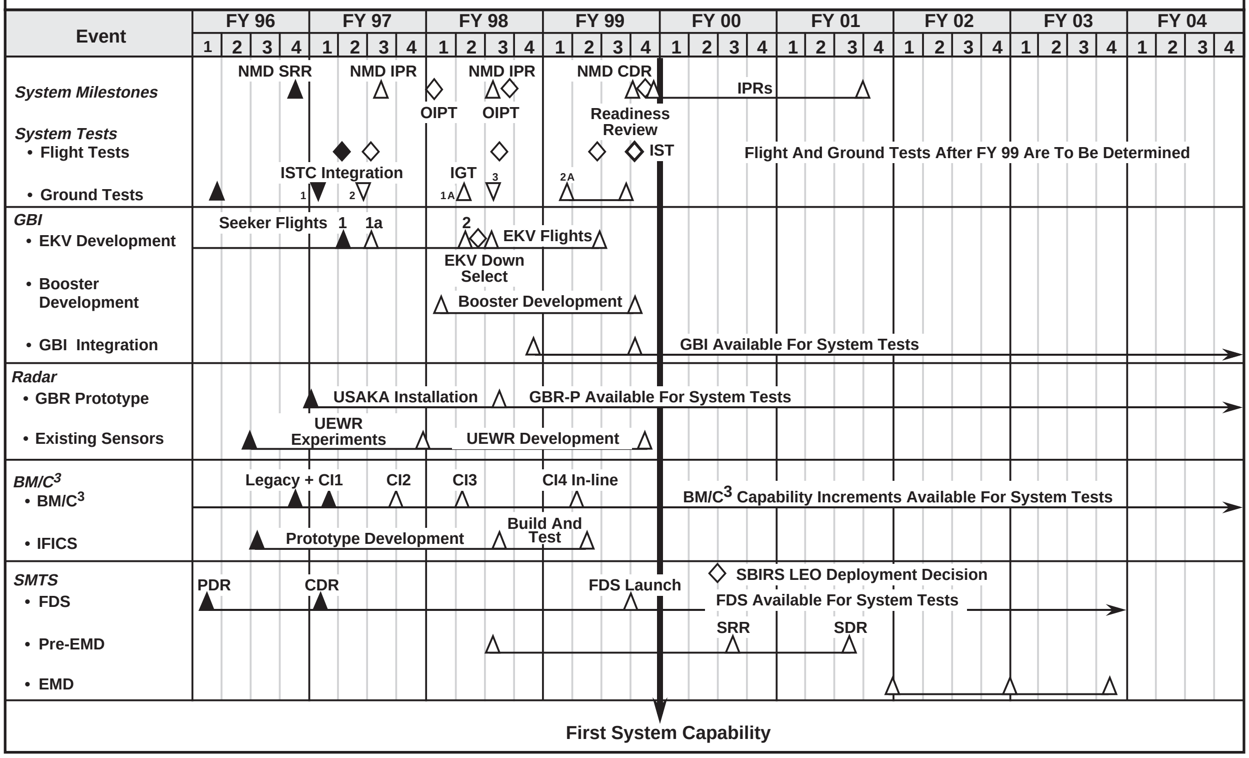
3.4 Program Overview

Since passage of the Missile Defense Act (MDA) of 1991, the part of the Ballistic Missile Defense Program designed to protect the United States against a limited strike has evolved from a program to acquire a system to a program to be ready to acquire a system for deployment. In July 1992 the Secretary of Defense sent Congress a plan to implement the MDA that called for deployment of production hardware in FY 2002 and options for fielding a User Operational Evaluation System (UOES) as early as FY 1997. Following the change of administrations in 1993 and an extensive Bottom-Up Review (BUR) of DoD programs, strategic defense objectives changed from acquiring the Limited Defense System part of the Global Protection Against Limited Strikes (GPALS) program to the NMD Technology Readiness Program. The Technology Readiness Program was intended to address uncertainty in the timing of when a threat to the United States might emerge. It was structured to increase the capability of the key elements of a strategic defense system so that, over time, deployment opportunities of increasing performance capabilities would be available. A second key objective of the Technology Readiness Program was to reduce the time to deploy an NMD system by planning efforts such as award of contracts in a manner that would save time after a decision to deploy were made.

In 1994 Congress responded to the Administration's Technology Readiness Program by endorsing a "hedging" strategy for national missile defense and emphasizing the importance of reducing lead-times for deployment of a very limited, prototypical defense capability against a "rogue" missile threat. Congress stated in the National Defense Authorization Act for FY 1995 that the "...objective (for the NMD program) should be to develop and test, as rapidly as available NMD funding will permit, a limited, UOES-type capability." Furthermore, the Secretary of Defense was asked to study how the Technology Readiness Program could be changed to meet a threat against the United States that could emerge at the end of 2000, 2005, or 2010. In 1995, the Director, BMDO presented to the Congress three excursions that addressed possible changes to the baseline Technology Readiness Program. One excursion showed how the baseline program could be enhanced to reduce risk and support an initial deployment by 2003. A second excursion showed how an NMD emergency response system could be deployed as early as 2000. A third excursion showed how advanced technology such as active sensors and directed energy could be accelerated to form a basis for more robust systems than in the NMD baseline program. All three excursions required additional funding to the FY 1996 President's Budget and Department of Defense Program Objectives Memorandum (POM) for the out-years.

With the completion of DoD's 1996 Program Update Review of the BMD Program and the resultant shift of focus from a technology readiness to a deployment readiness program, the Department decided to proceed with, and fully commit to, the first three years of the “3+3” program. In April 1996, the USD(A&T) designated NMD an MDAP ACAT-ID, which is currently in the Program Definition/Risk Reduction (PD/RR) phase. The NMD “3+3” program schedule is shown in Figure 3-3.

Figure 3-3. NMD “3+3” Schedule



To accomplish this strategy, the Department spent the additional $375 million appropriation added to the FY 1996 President’s Budget. In addition, the FY 1997-98 POM levels have been increased by $100 million for each year. Furthermore, the Department will spend the additional $325 million appropriated over the FY 1997 President’s Budget.

Currently, BMDO is focusing on developing the documentation for the late-August 1997 NMD Program Review. Program Review objectives are twofold: (1) to review program and documentation status and (2) to establish the NMD milestone schedule.

3.5 National Missile Defense Elements

BMDO is entering a procurement to obtain a Lead System Integrator (LSI) contractor for NMD. The LSI will integrate all NMD element development to include the GBI, GBR, BM/C^3, UEWR, FBXR, and SBIRS-Low when it becomes available. During an initial concept development phase, competing contractors will develop and deliver detailed plans and schedules for the follow-on execution phase, with a goal of providing the most cost-effective design to meet user requirements. Specifically, for example, contractors are required to conduct life cycle trade studies on

GBI booster options, including Minutemen and other new, modified, or off-the-shelf boosters. Plans and designs for other architecture elements may evolve during the concept development and execution phases. Accordingly, the system element descriptions which follow reflect the design concepts of individual development efforts as they currently stand. These elements may differ from those used in the ultimate LSI design selected for development.

3.5.1 Ground Based Interceptor (GBI)

The GBI element of NMD consists of a nonnuclear Exoatmospheric Kill Vehicle (EKV) mated to a high-speed booster in addition to launch and support equipment. The GBI will be capable of destroying intercontinental ballistic missile threats in the midcourse phase of flight based on handover from advanced sensors. It uses precommit and in-flight target update data provided by BMD sensors through the BM/C^3 element to determine booster fly-out trajectory, acquire the threat cluster, and designate the target for KV homing. In the endgame, the EKV seeker is used to identify the target from among other associated objects and home in on it. After selecting an aim point and performing final maneuvers, the EKV hits its target, destroying it by force of impact. Figure 3-4 identifies GBI components and provides a description of its technical characteristics.

Initially, the GBI program will focus on developing and testing the EKV to demonstrate the required capability for the NMD mission. Two contractors are developing EKVs based on distinctly different technical approaches. As a result of increased funding in FY 1996, the two competing efforts will continue through FY 1997. These experiments will reduce intercept flight test risk by providing the data necessary for the EKV to demonstrate onboard discrimination and target selection prior to intercept flights. Four EKV flight tests will take place in FY 1997-99 before the FY 1999 NMD system demonstration.

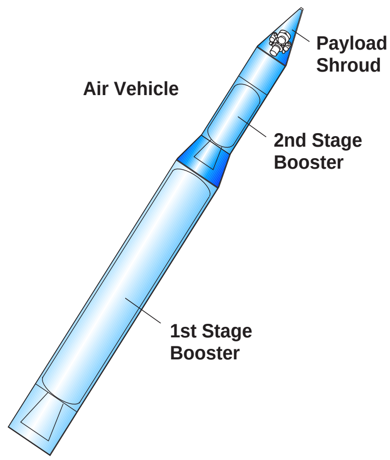
Beginning in FY 1998, the GBI program will develop a new booster or modify an existing booster which can satisfy NMD coverage and timeline requirements. The required launch and support equipment will also be developed. When the booster has been tested to ensure proper operation and payload deployment, it will replace the Payload Launch Vehicle (PLV) which is currently used in testing and is planned for use as a surrogate booster for the GBI in the FY 1999 IST. To achieve the objective NMD system capability, the GBI will incorporate increased hardening and any applicable component technology upgrades which have been developed in parallel with the initial EKV design.

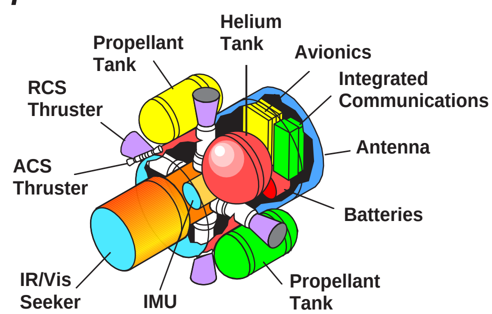
3.5.2 Ground Based Radar (GBR)

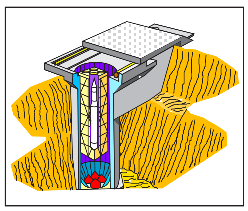
A GBR prototype is being developed as part of the three year NMD development phase to support flight testing and system integration. The NMD Ground Based Radar-Prototype (NMD GBR-P) (Figure 3-5) will leverage off existing TMD GBR technology. The NMD GBR is an incremental program that leverages developments of the Theater High Altitude Area Defense (THAAD) radar program to resolve the critical issue associated with development and deployment of an NMD GBR. Beginning in FY 1997, the THAAD Demonstration/Validation (Dem/Val) radar will be reconfigured into GBR-P, providing a cost and risk reduction. The NMD GBR-P effort will develop a test bed radar to resolve critical technology issues associated with development of an NMD-GBR and provide the primary fire control sensor to support integrated NMD system testing at the United States Army Kwajalein Atoll (USAKA).

Figure 3-4. GBI

System Components







Launch Site

Kill Vehicle Characteristics

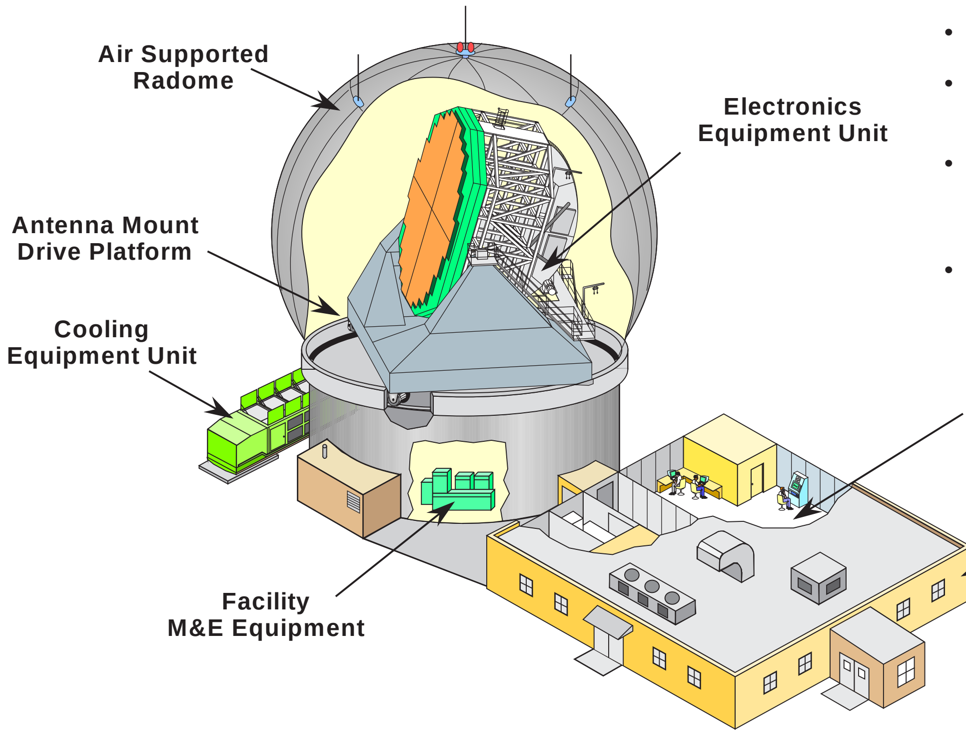
- Kill Vehicle (35-45 kg)
  - Multispectral Passive LWIR Seeker
    – HgCdTe Or Si:As FPA
  - Guidance And Navigation
    – IFOG Inertial Measurement Unit
    – Solid-state Accelerometers
  - Divert Propulsion
    – Liquid Bipropellant
    – High Acceleration
  - Cold Gas Attitude Control System
- Booster
  - 2 Or 3 Stages
  - > 7 km/sec Burnout Velocity

Description

- **GBI Is The Weapon Element Of NMD**
- **Interceptor Development / Testing Is Integrated With NMD System Development / Testing**
  - **FY 1997-98 Sensor Flights (IFT-1 And IFT-2)**
  - **FY 1998-99 Kill Vehicle Flights (IFT-3 And IFT-4)**
  - **FY 1999 NMD System Demonstration**
- **Focus Is On Deployment Readiness**
  - **“3+3” Development Strategy**

As a primary fire control sensor for the NMD system, the radar performs surveillance, acquisition, track, discrimination, fire control support, and kill assessment. To support precommit, the radar will plan and schedule its sensor resources to search autonomously or in response to a cueing handover, acquire, track, classify/identify and estimate object trajectory parameters. The radar will pass to the engagement planner all objects which it classifies as threat targets or other potential targets. The engagement planner will use these data to develop a weapon tasking plan for the interceptor and for the planning of sensor tasking required for postcommit. In postcommit, the radar schedules its sensor resources to continue tracking the target to provide an In-Flight Target Update (IFTU) and a radar target object map to the assigned interceptor while collecting data to aid in target kill assessment.

Figure 3-5. Ground Based Radar - Prototype (GBR-P)



- 16,896 T/R Modules
- 123 m^2 Aperture
- 2,000-4,000 km Range
- Mechanical Slew
  - ± 178 deg Az
  - 0-90 deg El
- Electronic FOV
  - 25 deg Az
  - 25 deg El

3.5.3 Upgraded Early Warning Radar (UEWR)

The NMD architecture incorporates existing Early Warning Radars (EWRs), which are part of the Integrated Tactical Warning/Attack Assessment (ITW/AA) System. When upgraded, the EWRs function as an early and midcourse tracking element prior to the deployment of the SBIRS-Low. The existing EWRs will require software and processing upgrades to track reentry vehicles effectively. BMDO is continuing its program to develop an Upgraded Early Warning Radar (UEWR). Figure 3-6 displays a typical UEWR.

The CONOPS for the UEWRs calls for cueing from the DSP to initiate a special search fence in the target's vicinity. After acquiring the missile, the EWR will concentrate energy on the missile and transmit tracking information to BM/C^3 assets over the time period that the radar tracks the missile.

A number of successful experiments, using modifications to the software of the PAVE PAWS and Ballistic Missile Early Warning System (BMEWS), show the UEWR's viability in performing early warning functions in support of the NMD mission. Based on these demonstrations, BMDO initiated a UEWR prototype program under an Air Force Executing Agent in FY 1997. Actual modifications to the UEWRs will not occur until a deployment decision is made. Other FBXRs could be developed and fielded to augment and fill the EWR radar coverage gap.

Figure 3-6. Upgraded Early Warning Radar

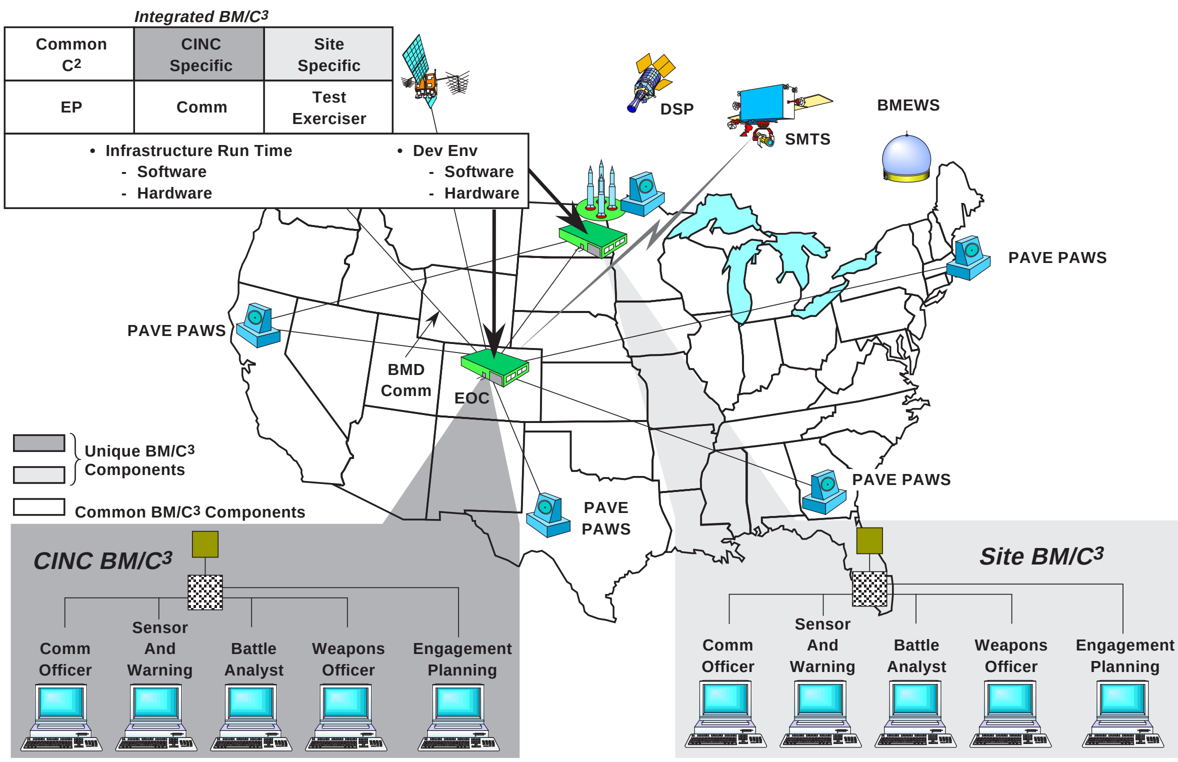
- **EWR (Other Existing Sensors)**
  - **Develop And Demonstrate Upgrades To EWR And Other Existing Sensors In Support Of NMD**
  - **Testing Of Prototype UEWR Software**
  - **Develop UEWR Simulation In Support Of Integrated Ground Tests (IGTs)**

3.5.4 Battle Management/Command, Control, and Communication (BM/C^3)

The NMD BM/C^3 element supports USSPACECOM and the North American Aerospace Defense Command (NORAD) Command and Control (C^2) of the NMD system with integrated C^2 decision support systems and automated engagement planning capabilities. The BM/C^3 element interfaces with existing C^2 systems and the NMD elements by a survivable communications subsystem comprised of line-of-sight radio frequency, Military Satellite Communications (MILSATCOM), landline/fiber-optic communications network, and the In-Flight Interceptor Communications System (IFICS). Figure 3-7 refers to the integrated BM/C^3 network for NMD. The BM/C^3 element functionally integrates the NMD system by supporting inter-element communications, processing sensor and intelligence data to create BM/C^3 knowledge bases that are used to support battle planning, C^2 decision making and sensor, interceptor and communications tasking balanced to best support command and human-in-control direction. The BM/C^3 element supports NMD BM/C^3 operations in peacetime and in all phases of conflict.

Additionally, an IFICS prototype is planned for development. The IFICS supports the transmission of BM/C^3 IFTU and Target Object Map (TOM) messages to the in-flight EKV that are required to refine targeting information and intercept the intended target. This effort will make use of available government communications systems to leverage an NMD IFICS prototype development.

Figure 3-7. Integrated BM/C3



The CONOPS for the BM/C^3 element calls for functionally redundant BM/C^3 personnel and equipment suites located near both the USSPACECOM/NORAD Cheyenne Mountain Center and the NMD intercept site. The BM/C^3 element design concept supports flexible operational configurations needed for USSPACECOM/NORAD NMD CONOPS dynamics as well as operational survivability in the event either site is degraded or unavailable.

The BM/C^3 project has successfully developed the initial BM/C^3 Capability Increment One (CI-1) and associated BM/C^3 Test Exerciser (TEx) capabilities, initiated User Assessment processes, and initiated design and development of BM/C^3 Capability Increment Two (CI-2). BM/C^3 CI-1 has been integrated into the Integrated Flight Test One (IFT-1) environment with BM/C^3 equipment suites at both the Kwajalein Missile Range (KMR) and the BM/C^3 Element Support Center at the Joint National Test Facility (JNTF) at Falcon AFB, Colorado, supported by a secure high data rate communications link. The test configuration will address the BM/C^3 element interfaces with the system test environments, the GBI test article, and will test BM/C^3 CI-1 functionality. BM/C^3 CI-1 will participate in IFT-1 and IFT-2 as well as Integrated System Test Capability (ISTC) Integration Test 1 and 2. BM/C^3 CI-2 will be integrated into this system's test environment to participate in IFT-3 and IFT-4 and Integrated Ground Test One-A (IGT-1A). CI-3 and CI-4 support test participation of increasingly complete BM/C^3 functionality required for an initial NMD deployment operational capability. Further the BM/C^3 project will continue the successful series of BM/C^3 demonstrations utilizing EWR systems to validate BM/C^3 capabilities to coordinate tasking of multiple sensor sources, cue sensors, and fuze track data for NMD purposes.

3.5.5 Space Based Infrared System (SBIRS)

The SBIRS Program, a necessary element in the objective NMD system, is an Air Force acquisition effort to field a consolidated space-based nonimaging infrared surveillance system that meets United States needs for missile warning, missile defense, technical intelligence, and battlespace characterization for the next two to three decades.

The SBIRS Program includes both high- and low-altitude components. The SBIRS-High component consists of four satellites in Geosynchronous Earth Orbit (GEO) and two infrared sensors on satellites in Highly Elliptical Orbit (HEO). The SBIRS-Low component, formerly known as Space and Missile Tracking System (SMTS), with satellites operating in Low Earth Orbit (LEO), complements SBIRS-High by providing a unique precision midcourse tracking capability to meet objective system performance in ballistic missile defense (both national and theater). A common ground-based processing capability will replace the DSP processing stations as well as Attack and Launch Early Reporting to Theater (ALERT) and will be the primary location for SBIRS mission processing, mission management, mission planning, and satellite and sensor control.

SBIRS-Low will be composed of multiple rings of small, lightweight spacecraft in low-altitude, inclined orbits. SBIRS-Low will have acquisition and track sensors onboard to detect, track, and discriminate missiles in the boost, post-boost, and midcourse phases. The acquisition sensor uses a wide field of view, and a short wavelength infrared scanning sensor to detect bright rocket plumes. As the boosters burn out, the narrow field of view staring tracking sensors take over, using medium and long wavelength infrared and visible detectors to provide precision tracking and discrimination.

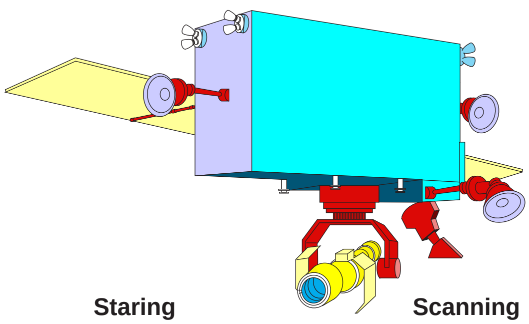
The SBIRS-Low component demonstration phase consists of two satellite efforts. The first is the Flight Demonstration System (FDS) to design, build, and fly two satellites which will demonstrate critical system capabilities in a real world environment. The second effort is the Low Altitude Demonstration System (LADS), which demonstrates critical sensor functions aboard a single satellite and maintains viable competition during the pre-EMD phase of acquisition leading to award of a single SBIRS-Low EMD contract.

The Office of the Secretary of Defense (OSD) recently directed that funding be provided for a SBIRS-Low initial launch in FY 2004, accelerating the program two years. The program is currently in the PD/RR phase of acquisition. Two contractor teams are currently competing with separate programs. TRW/Hughes is under contract to develop, fabricate, and fly two FDS satellites to be launched in FY 1999 to demonstrate operations and performance and to validate the design and costs of the SBIRS-Low concept. In September 1996, Rockwell was awarded a contract to provide risk reduction activities for SBIRS-Low. Rockwell will develop an alternative SBIRS-Low concept, LADS, which includes a flight experiment to be launched in FY 1999 and ground demonstrations to address additional operational aspects of SBIRS-Low.

Figure 3-8 provides a description of the SBIRS-Low component and a picture of the Flight Demonstration System (FDS) satellite.

Figure 3-8. SBIRS Satellite

Spacecraft



Staring Track Sensor

- Short Wave Infrared
- Medium Wave Infrared
- Medium-long Wave Infrared
- Long Wave Infrared
- Visible

Scanning Acquisition Sensor

- Short Wave Infrared

Description

- **Distributed Constellation In Multiple Rings**
- **Low Altitude, Inclined Orbits**
- **Small, Lightweight Spacecraft (≈600 kg)**
- **Wide Field Of View Acquisition Sensor**
  - **Horizon-To-Horizon Surveillance To Acquire And Track Boosters**
- **Narrow Field Of View Track Sensor**
  - **Above And Below-The-Horizon Tracking Of Boosters And Warheads**
- **Provides Passive Sensor Technology For Contingency Architectural Options**

Essential For Optimum Coverage

3.6 NMD Test Program

The NMD Test and Evaluation (T&E) program will be conducted in accordance with the NMD *Test and Evaluation Master Plan (TEMP)*. The NMD TEMP will establish the framework for a comprehensive NMD T&E program. The TEMP will capture a dynamic T&E process that accommodates an evolving architecture, supports the threat-driven acquisition strategy, baselines T&E resources, and is consistent with maturing program documentation.

In coordination with the developmental and operational test communities and the NMD program manager, the System Test director will ensure the effective determination of achieved system performance via testing. The NMD test program encompasses a continuum of simulations, IGTs, IFTs, and ISTs to assess the capability of the NMD system to perform the national BMD mission specified in the Joint ORD. An aggressive simulation program including complex Hardware-in-the-Loop (HWIL) and Software-in-the-Loop (SWIL) simulations will be used to make effective use of limited flight testing opportunities.

The NMD Deployment Readiness T&E program will demonstrate the incremental capability and interoperability of BM/C^3 systems, GBI, GBR, UEWR, forward-deployed X-Band radar, and space-based sensor elements of NMD. An evolutionary program of ground and flight tests will culminate with a fully integrated test of these systems in conjunction with IFT-5 in FY 1999. This test will demonstrate system performance effectiveness against a representative threat before a system deployment decision is needed. The T&E Program Integrated Product Team (IPT) established FY 1999 Test Program Objectives in the NMD TEMP. Numerous IGTs and a total of five

IFTs will be conducted prior to the 2000 deployment decision review. Combined Development Testing and Operational Testing (DT/OT) will also be conducted during the initial development phase as a means to support an early deployment decision if necessary.

The NMD ISTC Hardware- and Software-in-the-Loop (HWIL/SWIL) System Test Integration Laboratory will be used to evaluate the system interfaces prior to this flight test. The NMD T&E program is based upon an incremental evaluation of the critical technical parameters of the system as prescribed to the test program in a set of operational requirements from the system engineering process. These critical technical parameters are Engagement Response Time, System Tracking Performance, System Discrimination Performance, System Engagement Performance, Multiple Engagement Performance, and System Kill Assessment Performance. Key features of the test program designed to evaluate these parameters and reduce acquisition risk include:

- Demonstrate integrated system capability and interoperability before the 2000 Deployment Decision;
- Accelerate development of the NMD Capability Test Tool for extensive and repeatable evaluation of element interfaces and system capability;
- Judicious use of flight tests to anchor models and simulations and NMD Integrated System Test Capability Tool;
- Leverage individual element test and simulation opportunities to collect data and evaluate system issues;
- Maintain focus on system-level functional tests while demonstrating time phased capabilities; and
- Reduce cost and delays through exploitation of Targets of Opportunity, demonstrations, and system simulations.

Given the prohibitive costs of conducting a statistically representative set of NMD flight tests, the development and use of the NMD ISTC allows achievement of statistical confidence in the readiness assessment of an NMD system to be deployed. The shift in focus to the NMD Deployment Readiness Program allows the individual element data processors and software to be available sooner, integrated into the NMD ISTC, and evaluated prior to the FY 1999 IST. This allows early identification of system interface design issues and risk associated with live flight testing. FY 1999 Test Program Objectives include demonstration of:

- End-to-end integrated system performance;
- End-to-end target detection, acquisition, tracking, correlation, and handover performance;
- Real-time discrimination performance;
- NMD system kill assessment capability;
- The ability of the NMD system to develop and coordinate battle engagement plans; prepare, launch, and fly out a designated weapon; and kill a threat representative target;

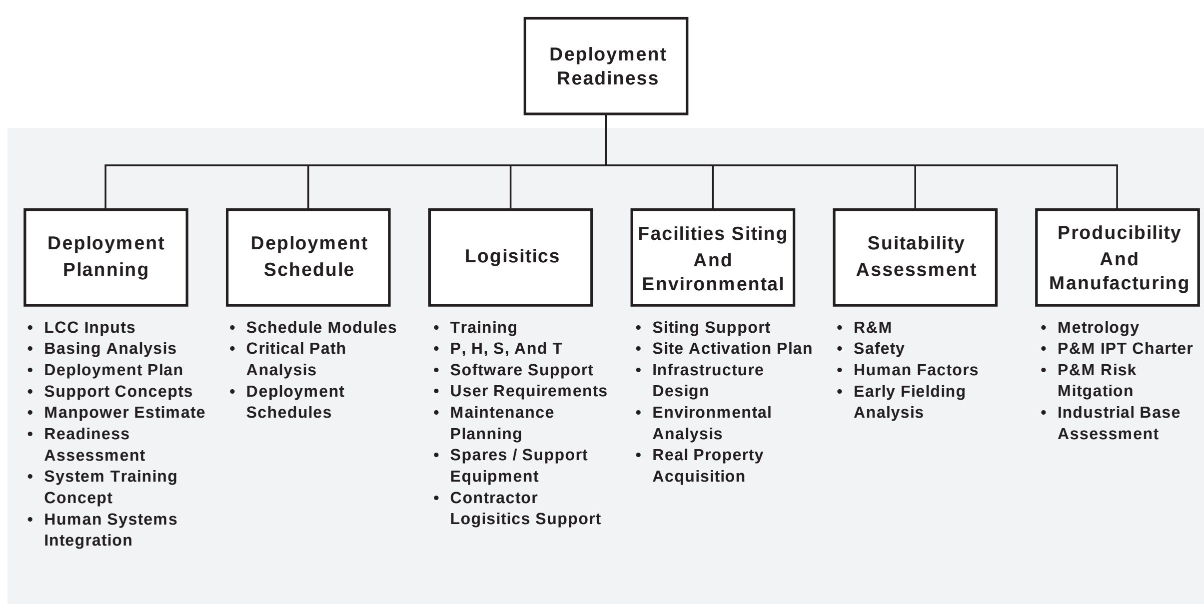
- Integration, interface compatibility, and performance of the NMD system, subsystem hardware and software, and human-in-control operations.

Modeling and Simulation (M&S) are used in the NMD Deployment Readiness Program to reduce the time, resources, and risks of this highly accelerated development process. Simulations and models are used extensively in the T&E program to represent complex environments and overcome the limitations of actual live testing. Areas of particular application include support to test planning, test design, test execution, and data analysis and reporting. Systems engineering and integration organizations employ M&S for system requirements trade-offs, balancing, and performance assessments against a wide range of threat scenarios.

3.7 Deployment Readiness

NMD Deployment Readiness Program efforts are being developed based on the requirement that an effective, suitable, and sustainable system can be deployed within three years following a deployment decision. The NMD deployment readiness process comprises a series of complimentary functional tasks including Deployment Planning, Deployment Schedule, Logistics, Facilities Siting and Environmental, Suitability Assessment, and Producibility and Manufacturing, as depicted in Figure 3-9 and described below.

Figure 3-9. NMD Deployment Readiness Activities



3.7.1 Deployment Planning

The shift in the NMD Program from technology readiness to deployment readiness has driven an acceleration toward more intensive and integrated planning studies to achieve a more efficient deployment capability at lowest cost and risk. Integrated deployment planning is keyed to the progress of technical developments, the results of the FY 1999 IST demonstration, and the anticipated threat. The NMD Integrated Deployment Plan (IDP) provides the capability for deployment of an initial capability in three years following the deployment decision. A Deployment Readiness IPT will develop the NMD IDP, which is a comprehensive and evolving document which provides "system focus" to deployment, integrates system elements, and maintains deployment planning status.

3.7.2 Deployment Schedule

BMDO will continue to conduct critical path analysis of the development and deployment schedules to identify time reduction opportunities, resource requirements, and risk areas.

3.7.3 Logistics

Logistics support is a series of activities that will be developed and procured in compliance with the BMDO-approved system support concept. The NMD Program will plan for and encourage the use of standard support and test equipment.

3.7.4 Facilities Siting and Environmental

BMDO is conducting facility, site, and National Environmental Protection Act (NEPA) work based on the North Dakota Area Siting Study for an ABM Treaty-compliant NMD system and has undertaken many studies to determine the potential consequences to the environment of its programs. BMDO is planning to complete an environmental analysis of nine alternative sites in FY 1999. At the same time, as required by NEPA, BMDO is using the DoD's Environmental Impact Analysis Process (EIAP) to integrate environmental considerations into its decision making and to establish the required timing and scope of environmental impact analysis documentation in support of program decisions.

Preliminary site activation planning is in process for a "prototype site," a combination of Grand Forks AFB, Stanley R. Mickelsen SAFEGUARD Complex (SRMSC), and Minot AFB, to prepare for the Deployment Decision Review. Early planning for site activation at such a site will allow the development of critical planning data and will greatly reduce deployment risk to an actual deployment site. Other site activation tasks include writing and executing a site activation plan, providing site facilities and infrastructure, installing and testing, and transition planning.

3.7.5 Suitability Assessment

The NMD Program will implement a comprehensive approach to ensure that human performance and resource considerations are appropriately and adequately addressed through the identification of risk areas and mitigation actions that conform to OSD policies and guidance.

In addition, BMDO will also incorporate a structured Reliability and Maintenance program built around the NMD systems engineering approach which eliminates specifying availability at the system level, relying rather on specifying system effectiveness. Operational availability will be addressed at the subsystem element level, in response to potential Joint ORD requirements designated at the element level.

3.7.6 Producibility and Manufacturing (P&M)

In early 1996, the updated BMDO P&M Strategy was issued, emphasizing innovative approaches, vision, strategies, tools, and risk reduction processes for P&M issues. A key element in this process is the P&M Program Integrated Product Team (P&M PIPT), established to address and resolve risks associated with transitioning BMD systems from development to production.

3.8 System Engineering and Integration (SE&I)

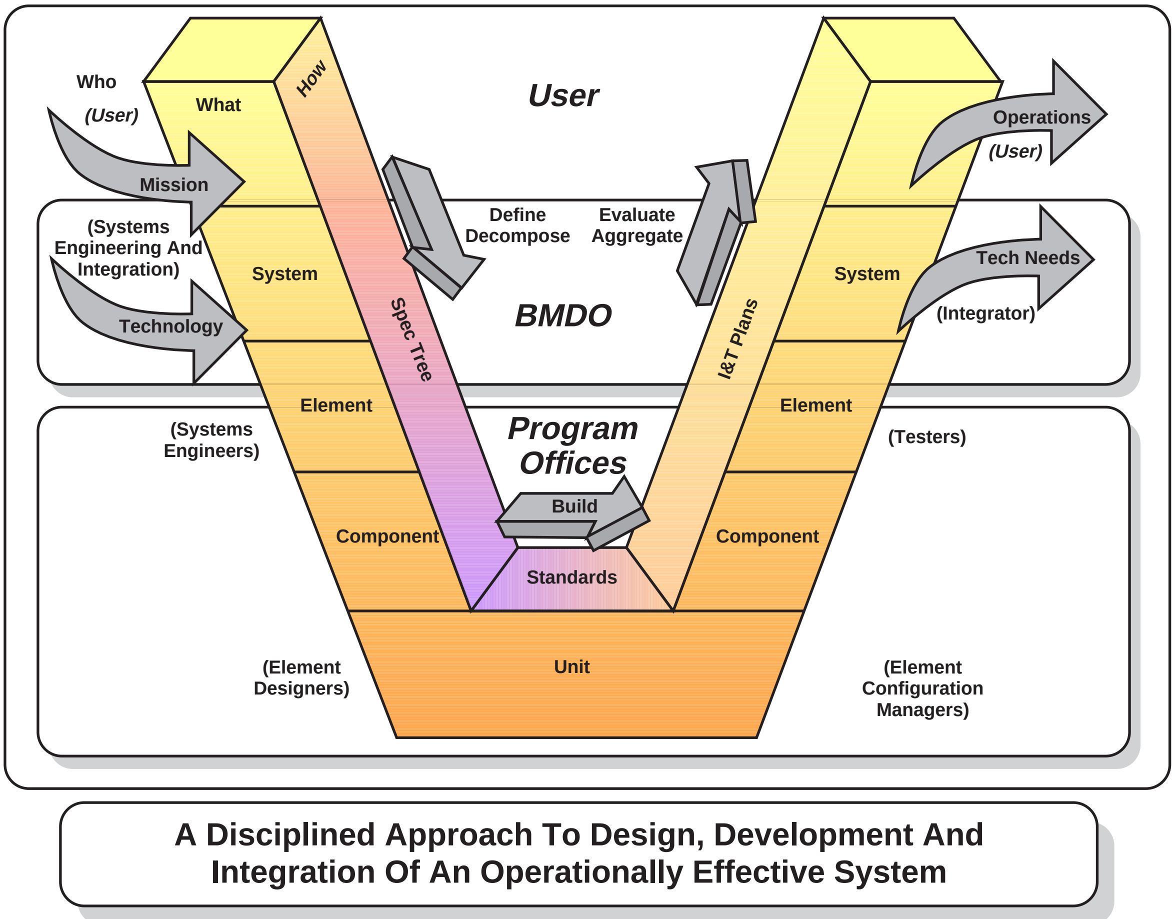
CRD performance and operational parameters for NMD are translated into system development parameters and allocated to system elements through the BMDO system engineering process (see Figure 3-10). Requirements are provided to the NMD development community in the NMD SRD. Further requirements definitions are provided for the elements of the NMD system in the Element Requirements Documents (ERDs). The NMD SE&I Program consists of activities necessary to establish the readiness to acquire an NMD system capability consistent with the SRD and ERDs.

NMD system engineering efforts will result in the definition of system/element test requirements for NMD flight testing scheduled to begin in FY 1997 with EKV seeker flight tests. As element and system tests are conducted, results will be evaluated against test predictions, system and element requirements. Where necessary, results will be used to adjust and modify element designs to rebalance the NMD system. Refining system-level derived requirements based on demonstrated tests will validate system element integration while ensuring interoperability and compatibility between NMD elements.

BMDO will execute an SE&I process with four principle objectives. One, SE&I will complete the necessary development and integration of an NMD Capability 1 “3+3” system to be ready for demonstration in FY 1999 based on the threshold requirements in the Joint ORD. Two, SE&I will establish the objectives and validate the results of the FY 1999 IST. Three, the SE&I process will produce incremental upgrades of the Capability 1 system on a path toward the Capability 2 system, consistent with the objective requirements in the Joint ORD. Finally, the SE&I process will enable fielding of the NMD system and subsequent upgrades.

Given the uncertain nature of the ballistic missile threat, the SE&I requirements strategy is designed to accommodate both the threshold and objective requirements by setting sights on the horizon and defining NMD system requirements for Capability 2 while going back and defining Capability 1 requirements which evolve directly to Capability 2, subject to element availability. This strategy rests on three strengths. One, it will provide for the efficient execution of NMD strategy. Two, it will permit requirements traceability to suit user needs. Three, this SE&I requirements strategy will meet user requirements for a rapidly deployable Capability 1 while providing for an efficient evolution from Capability 1 to Capability 2.

Figure 3-10. System Engineering And Integration In NMD



Chapter 4

Supporting Technology Development Strategy And Programs

Chapter 4
Supporting Technology Development Strategy And Programs

4.1 Technology Investment Strategy

The Ballistic Missile Defense (BMD) technology investment strategy for sustainable development is to acquire systems that meet today's requirements and, at the same time, to anticipate potential future BMD requirements and the technology needs of tomorrow. Accordingly, these BMD efforts concentrate on affordable, high payoff technologies, including those available through cooperative programs with our allies, that can:

- Enable and assure the continuing vitality and potential National Missile Defense (NMD) and Theater Missile Defense (TMD) improved performance;
- Demonstrate the technology base to defend against advanced threats such as maneuvering targets, straightforward countermeasures, advanced submunitions, and Weapons of Mass Destruction (WMD); and
- Offer alternate system approaches (architectural flexibility) that can provide major increases in TMD and NMD capability against the current and evolving threat.

In essence, BMDO is developing the technology essential to meet the BMD mission in future years. In accordance with Congressional direction, BMDO maintains the follow-on support technology programs for BMD. Advanced technology efforts that either directly support future TMD and NMD system developments, or hold significant promise for advanced BMD systems, remain under the management responsibility of BMDO.

4.2 Technology Needs

To maintain the viability of a BMD architecture over time, technologies being developed must provide options for improvements to deployed systems or replace those systems with new capabilities to respond to a range of needs. Among the most important of these needs are capabilities to:

- Meet straightforward countermeasures such as decoys or electronic countermeasures;
- Cope with threat evolution such as advanced submunitions that improve the effectiveness of the attacking missile, longer range missiles that enlarge the areas that can be attacked, and maneuvering and less observable targets;
- Cope with threat evolution that presents the United States with rapidly developing crisis situations where there is insufficient time to deploy short- and mid-range systems to a theater of operation, or with situations where there is no friendly territory or international waters suitable for deploying such systems; and
- Handle proliferation of ballistic missiles and an increasing number of countries possessing the technology for WMD. This proliferation demands greatly expanded battle

space, increases the potential for surprise, and leads to the need for rapid deployment of TMD to counter rapid escalation of a conflict, or for continuous global Boost Phase Intercept (BPI) coverage.

To prepare to meet these future needs, BMDO is investing in the high leverage technologies that can provide:

- The capability to intercept ballistic missiles in their boost phase of flight. Space Based Laser (SBL) technology could address all of these needs, as well as reduce the burden on midcourse and terminal-tier defenses. This is also the only advanced technology that could provide a continuous, global BPI defense;
- Highly effective and affordable concepts for executing boost phase intercepts of ballistic missiles using kinetic energy interceptors launched from high-altitude, long-endurance Unmanned Aerial Vehicles (UAVs);
- Exoatmospheric and endoatmospheric intercept capability with high probability of kill at reduced technical risk and program cost to expand battlespace, increase defended area coverage, and provide quick response solutions to theater defense;
- Multisensor detection and tracking that extends through the missile flight path to provide the earliest possible alert, and midcourse tracking; and
- Algorithm development for the identification, discrimination, aim point selection, and kill assessment to support early assured targeting and tracking within the battlespace environment, thereby achieving effective battle management.

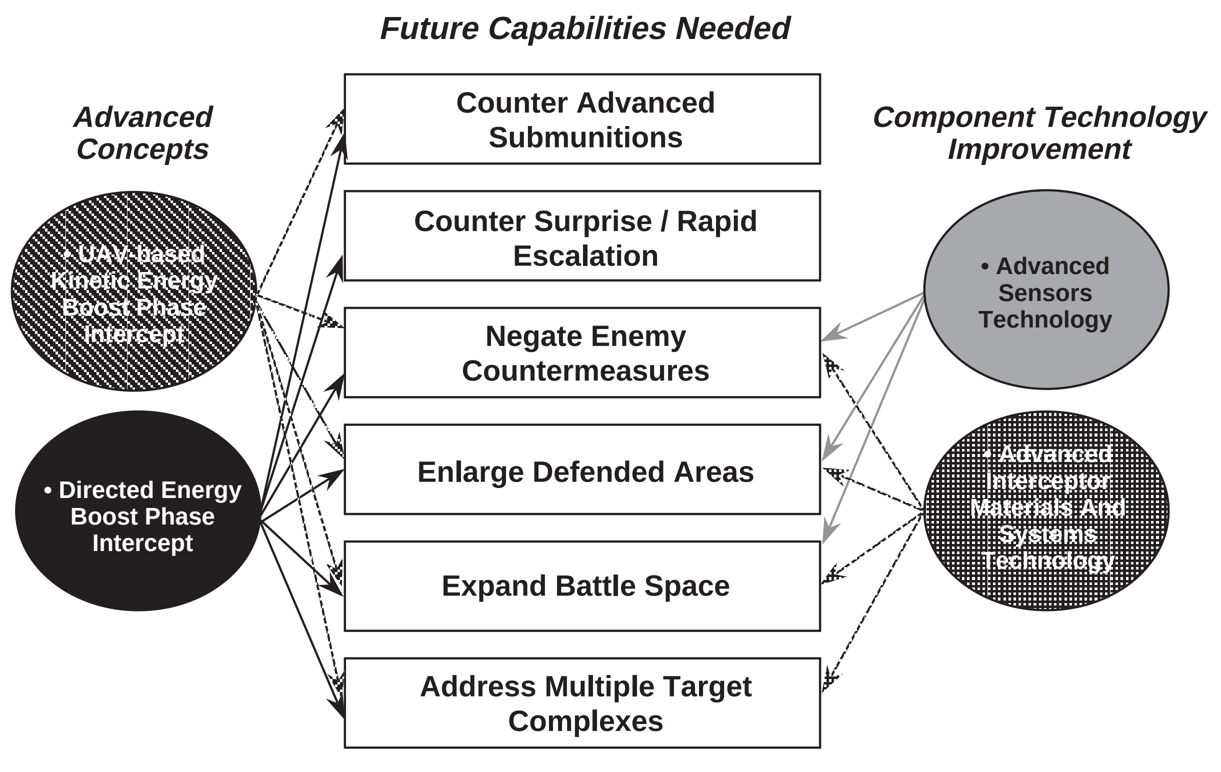
Figure 4-1 diagrams the future threat in terms of capabilities needed and potential technology solutions. Arrows point from each critical technology solution to the mission needs which that solution addresses.

4.3 Program Overview

The current advanced technology development program is structured in four major segments: UAV-based Kinetic Energy Boost Phase Intercept, Directed Energy Boost Phase Intercept, Advanced Sensor Technology, and Advanced Interceptor Materials and Systems Technology. Figure 4-2 provides the current schedule for each segment.

Early BPI of ballistic missiles reduces the number of ballistic missiles reaching their terminal phase of flight. Early BPI can cause missile debris to fall on enemy territory and any BPI will cause the missile to fall short of the intended targets. BPI could serve as a powerful deterrent against further development, proliferation, or actual use of chemical, biological, or nuclear warheads. The importance of BPI capability increases significantly as the range of the ballistic missile threat increases and the types of warheads proliferate. Intercept of a missile in its boost phase near the point of launch enables larger defended areas and simplifies the identification and discrimination problems associated with advanced submunitions, and threat penetration aids. The major objective of BPI programs is to demonstrate the required technologies in the relevant operational environment in order to establish system utility.

Figure 4-1. Technology Needs



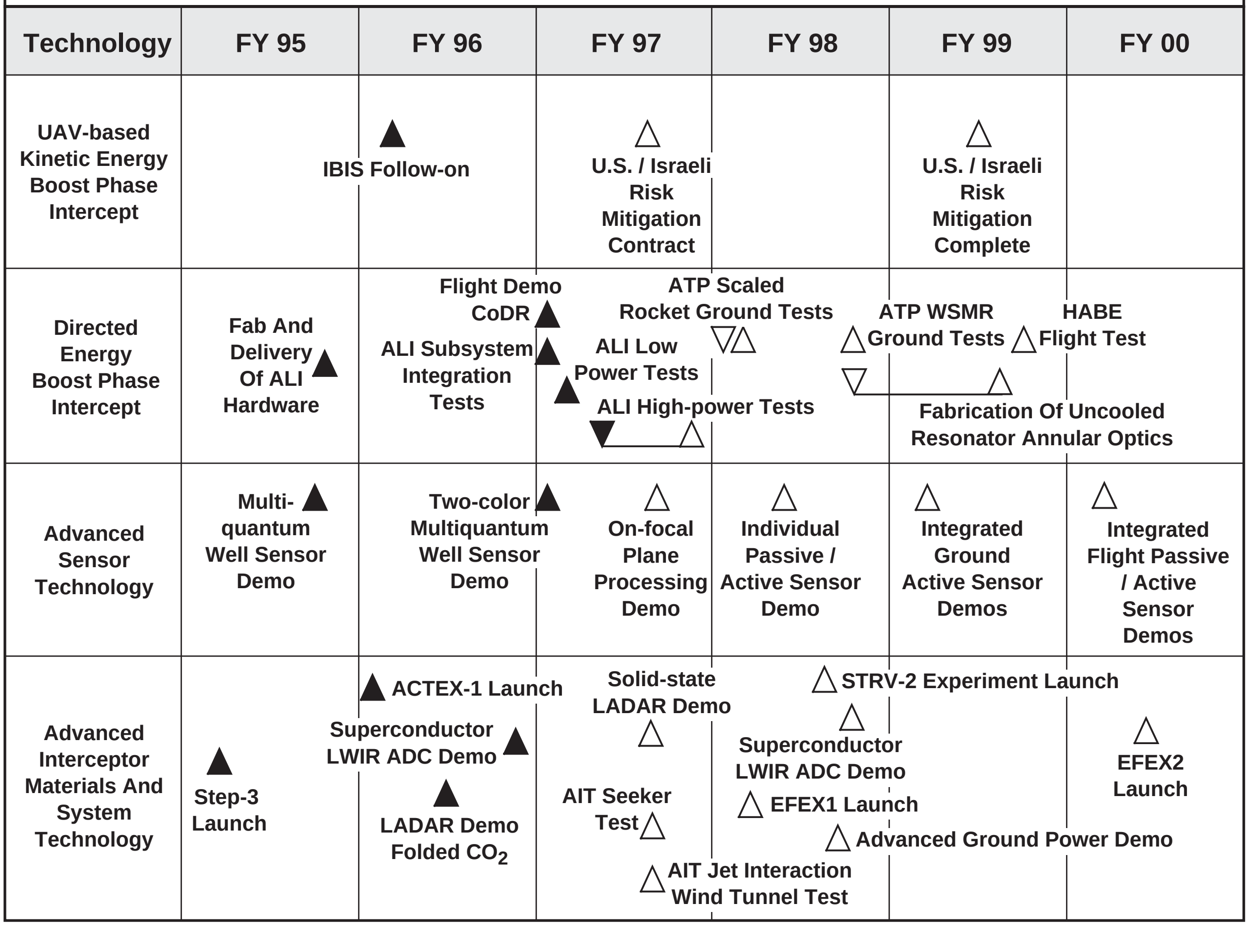
Continuous, global BPI coverage is essential for rapidly developing situations where there is insufficient time to deploy a short-range system to the theater or where geography and/or the political environment does not provide suitable territory or international waters for such a deployment.

4.3.1 Unmanned Aerial Vehicle (UAV)-based Boost Phase Intercept (BPI)

The UAV-based BPI program covers two efforts: Task 1 - Boost Phase Intercept System Risk Mitigation, and Task 2 - Cooperative UAV-based BPI Concepts. Both tasks are based on the Israeli Boost Phase Intercept System (IBIS) concept and support a cooperative U.S./Israeli risk mitigation initiative. Task 1 will refine (risk mitigate) the IBIS concept of unmanned aerial vehicles armed with kinetic energy interceptors to provide the means of destroying thrusting Theater Ballistic Missiles (TBMs) in their boost phase of flight. Task 2 will leverage off previous and ongoing U.S. investments in Infrared Sensors to develop an Infrared Search and Track (IRST) capability able to be deployed on a UAV BPI system. System components to be mitigated include kinetic energy interceptors, UAVs, search and track sensors, and Battle Management/Command, Control, Communications, Computers, and Intelligence (BM/C^{4}I). In addition, the Concept Of Operations (CONOPS) will be refined.

The program will develop and demonstrate critical technology elements to support UAV-based BPI concepts. The program will leverage existing contracts and technologies. Piece part demonstrations will validate critical technologies such as moderate velocity lightweight air-launched interceptors, a missile seeker head, and will provide (1) new component and system capabilities with reduced costs and risks compared to current weapon systems; (2) reduction of costs and risks

Figure 4-2. Advanced Technology Schedule



to support an acquisition program; and (3) technical solutions for contingent residual BPI capabilities for theater defense.

4.3.2 Directed Energy Boost Phase Intercept

The Directed Energy Boost Phase Intercept Program consists of the Space Based Laser (SBL) Program and the Acquisition, Tracking, Pointing and Fire Control (ATP/FC) program. These high-power chemical laser components and technologies were developed over the past 15 years specifically for the boost phase intercept mission. These two programs were restructured in FY 1996 to reflect Congressional and DoD guidance, which provided $45M of additional funding, as well as an additional $70M in FY 1997.

The major building blocks have been developed, but system integration and test lie ahead. The remaining tasks are to integrate the high-power laser with the large optics beam director and test in a ground demonstration Alpha/LAMP Integration (ALI); to integrate and test ATP/FC hardware and software onboard High Altitude Balloon Experiment (HABE); to integrate laser, beam control, and beam director hardware with ATP/FC hardware and test; and to integrate the hardware in a space-qualified SBL Readiness Demonstrator (SBLRD) vehicle for ground and flight testing.

In FY 1996 Congress provided additional program funding to continue ALI, accelerate design activities for a space demonstration, produce a CONOPS, design requirements for an operational SBL system, and revitalize the SBL technology development efforts. The $45M Congressional addition was released in April 1996, obligated within 60 days and fully expended by December 1996, allowing BMDO to preserve vital infrastructure, restore the ALI program to its original scope, and continue the ATP/FC program.

The current plans bring Alpha back to test readiness and, with Congress-added funding, completes ALI high-power tests in FY 1997. The Alpha device and facility have been reactivated and the test team reconstituted.

The ATP/FC program completed fabrication and test of the illuminator laser that will be used in the field experiments. Integration into the HABE platform was completed and testing begun. With the FY 1997 Congressional increase, integrated ground testing will be completed in early FY 1998, and the first flight test will occur in FY 1999.

4.3.3 Advanced Sensor Technology

This program is an evolutionary effort to improve tracking of ballistic missiles by improving surveillance sensors, and advancing signal processing techniques for efficient and definitive identification and discrimination. Development efforts emphasize compact, adaptable, efficient passive Focal Plane Arrays (FPA) and precision active optical ranger/illuminators. Integrated detection/signal processing demonstrations are scheduled for FY 1997.

Thereafter, the program develops the next generation of BMD sensing technology. Resources will also be used to develop data fusion and discrimination. Intermediate milestones address a building block approach of the system hardware and algorithm development. Ground testing of these integrated technologies will begin in FY 1998. The ultimate objective will be achieved in a FY 2001 flight, using available aircraft platforms, that will demonstrate fusion of surveillance sensor data from radar, Laser Detection And Ranging (LADAR), and Long Wavelength Infrared (LWIR) sensors with onboard signal processing, tracking, and discrimination algorithms. The Proof-Of-Principle (POP) detection, tracking, and discrimination demonstrations are planned to validate the maturity of technology prior to infusion into any acquisition program.

An effort related to the sensor program involves understanding the phenomenology associated with target signatures against different backgrounds. BMDO continues this critical technology program and has conducted a number of activities with our allies aimed at extending phenomenology databases through acquisition and exchange.

The Midcourse Space Experiment (MSX) satellite is BMDO's only on-orbit platform that couples a Low Wavelength Infrared/Very Low Wavelength Infrared (LWIR/VLWIR) sensor with state-of-the-art visible and ultraviolet sensors. It will provide high-fidelity optical data on target signatures and long duration global and seasonable background clutter data. Information from this program will mitigate design risk, enable optimal system design, and minimize life cycle cost of future systems (e.g., Space Based Infrared System (SBIRS)).

4.3.4 Advanced Interceptor Materials and System Technology (AIMST) Program

The AIMST program is based on the fundamental premise that technology investment is not an option but rather a requirement for achieving the BMDO mission. The focus of the program is therefore on providing technologies for BMDO elements which reduce technical risk, enhance capabilities, and increase affordability. Technology insertion is accomplished through extensive ground, airborne, and space demonstrations. Five major categories are addressed:

1. Technology which will ensure high signal/noise images for interceptor and surveillance optical sensors; active and passive vibration control and use of noncontaminating optical baffles and low noise superconducting signal processing electronics.

2. Development of lightweight, high stiffness, advanced composite structures and components which utilize low-cost, single-step fabrication methodologies to provide cost-effective weight growth mitigation for all BMDO system elements.

3. Provide essential data to BMDO systems which enable design of effective sensor, surveillance and interceptor systems. This includes data on performance of critical microelectronic components in the space radiation environment; Medium Wavelength Infrared (MWIR) background/clutter data at high latitudes as a function of altitude and seasonal variation; micrometeorite and debris fluence at mission altitudes, response of key materials and coatings to the space environment, and basic engineering data on structural response and sensor window performance during ultrahigh-speed (>3 km/sec at 60 km altitude) endoatmospheric flight. BMDO tests on advanced materials for use in Infrared (IR) windows has included samples from several allied nations including the United Kingdom (U.K.) and Japan.

4. Development of interceptor components necessary to achieve long-range threat detection, accurate homing guidance, and aim point selection for hit-to-kill interceptors. This includes high-sensitivity, uniform passive infrared LWIR seekers, Laser Radar (LADAR), and data fusion processing technologies. Emphasis is placed on increasing output power, miniaturization, and waveform generation to support onboard imaging. The ultimate objective will be achieved in interceptor flight tests in FY 2002 that will demonstrate onboard fusion of active and passive data to detect, track, and discriminate. The POP demonstrations are planned to validate the maturity of the technology and to demonstrate the reduced dependence of interceptors on external sensors to perform hit-to-kill, prior to infusion into any acquisition program.

5. The Atmospheric Interceptor Technology (AIT) portion of the program will develop, integrate and demonstrate the kinetic kill vehicle technologies for performing hypervelocity hit-to-kill intercepts of TBMs within the atmosphere. The demonstrations will validate the solutions to critical kinetic kill vehicle technologies and will provide: (1) new capabilities with reduced costs and risks compared to current interceptor weapons systems, and enhancements to other interceptors under development; (2) reduction of technical risks and costs in support acquisition programs through direct technology insertions; and (3) technical solutions to provide theater defense interceptor capabilities for contingencies not currently addressed by the TMD system programs.

The program uses existing contracts and technologies currently under development to reduce schedule and cost, and will be planned and conducted with BMDO, Air Force, Navy, and Army elements to make maximum use of existing Service infrastructures. The AIT project will participate in the UAV/BPI Studies and the Navy Theater Wide requirements studies. As a result of a $40M plus-up in the appropriated funding level, AIT will conduct the following work in FY 1997:

- Complete prototype seeker development and conduct initial hardware-in-the-loop test;
- Conduct cooled window and forebody aero-optic shock tunnel tests;
- Conduct cold-gas jet interaction wind tunnel tests;
- Complete preliminary software specifications;
- Conduct System Requirements Review (SRR);
- Conduct preliminary of solid Divert and Attitude Control System (DACS) and deliver DACS Ground Test Unit;
- Complete integrated avionics unit final design;
- Fabricate and integrate vehicle structures;
- Conduct Preliminary Design Review (PDR) for flight test vehicle; and
- Conduct millimeter wave (RF) technology development.

The Atmospheric Interceptor Technology program has effectively leveraged the expertise and resources of other agencies and allied nations in collaborative multinational, multiagency programs. This approach minimizes direct cost to BMDO and increases the effectiveness of technology development and demonstration efforts.

4.4 BMD Exploratory Science and Technology Program

The goal of the Exploratory Science and Technology Program is to identify, nurture, develop, demonstrate, and transition innovative ideas and approaches to BMD technology. The projects sponsored by the program are structured to exploit science and technology to improve performance, weight and volume, producibility, and affordability of future BMD systems. Many examples of successful research, demonstration, and transition are already documented, while many new ones are in the pipeline.

The Exploratory Science and Technology Program has two major thrusts: The Innovative Science and Technology (IS&T) contracted research program, and the Small Business Innovation Research (SBIR) program. Unlike other BMDO projects that fund near-term technology and testing efforts, the IS&T program is an exploratory science and technology initiative that invests seed money in high-risk, potentially high pay-off technologies that could significantly change how BMDO develops future systems. Technologies include next generation sensors, power, information processing, optics, advanced materials, propulsion, and communication. A primary goal is to conduct proof-of-concept demonstrations that transition breakthrough technology to BMD development programs. Planned and funded by BMDO, the bulk of the program is technically managed by Science and Technology Agents affiliated with defense and other government research agencies, with the principal investigators often coming from academia as well as industry.

4.5 Technology Transfer and Dual Use

Much of the research pursued by BMDO has broad application to meeting overall DoD needs and potential for civil and commercial applications. A second important objective is, therefore, to conduct a portion of the BMDO research efforts in a manner that enhances this technology transfer. For ten years, the Office of Technology Applications (OTA) within BMDO has focused on moving BMD technology out of the DoD and other Federal Laboratories and into the commercial market place and other agencies. It has been a model program, working closely with government, universities, and industry. To date, the OTA program documented the following statistics from its commercialization efforts: 45 new spin-off companies started, 234 new products on the market, 551 patents granted, 221 patents pending, 54 new ventures (licensing agreements, strategic alliances, third party agreements, partnerships, etc.), and started 33 cooperative research and development agreements. Each of these emanates from a BMDO-sponsored technology. Table 4-1 describes a sampling of BMDO research technologies and their dual use potential.

Often an initial investment of BMDO research and development funding is greatly leveraged by funding from other government or commercial sources. Activities of BMDO's SBIR are a case in point. Market capitalization, the high-tech small business community that the SBIR program supports, is considered just one of the metrics that can be utilized to measure the success of the program overall.

4.6 Significant Accomplishments in 1996

Some technology accomplishments for 1996 are briefly highlighted. The accomplishments are representative of BMDO's technology program and illustrate the broad spectrum of activities required to support TMD and NMD.

In the Solar Concentrator Array With Refractive Linear Element (SCARLET) program, the flight qualification for SCARLET I was completed. The next generation design, SCARLET II, was completed and 100 engineering prototypes of the 24% efficient flight solar cell were delivered.

In the Laser Communications (Laser Com) program, a successful mountaintop-to-mountaintop test was conducted, with a data rate of 1.2 Gbytes per second.

In the Russian Hall Effect Thruster Technology (RHETT) program, RHETT I was successfully ground demonstrated.

The MSX satellite was successfully launched from Vandenberg Air Force Base (AFB) on April 24, 1996. Within days it began collecting IR, visible, and Ultraviolet (UV) data on celestial, earthlimb, and hard earth backgrounds. In addition to several cooperative target data collections, the first MSX Dedicated Target (MDT-II) was successfully launched on August 31, 1996. MSX also suc-

Table 4-1. BMDO Technology Dual Use Potential

Research Area	Impact On BMD Capabilities	Potential For Military And Civilian Applications
Sensors		
• 150 Kelvin Cooler	• Mirror And Baffle Cooling Of Spacecraft Sensor	• Cooling For Electronic And Computer Systems
• Indium Antimonide Infrared Arrays	• Primary Sensor For Objective THAAD Missile	• Developed Into Infrared Detector For Civil, Safety And Law Enforcement IR Camera System
• Quantum Well Infrared Photodector (QWIP) Focal Plane Array (FPA)	• Higher Operability, Lower 1/f Noise, Higher Radiation Hardness And Less Than 5% Of The Cost Of HgCdTe Based FPAs	• Airborne And Spaceborne Warning Systems, Earth Observation Satellites, Pollution Monitoring
• Staring Si Impurity Band Conduction Extremely Sensitive Focal Plane Arrays (FPAs)	• FPAs Sensitive In The 4-25 Micron Region, High Sensitivity For Extended Range Sensing	• Incorporation Into NASA's Space Infrared Telescope Facility (SIRTF)
• Low Power, Lightweight 65K Cryocooler	• Long-term Time On-orbit Of Space And Missile	• Tactical Infrared Search And Tracking Systems, Cryogenic Computers, NASA Remote
Optoelectronic Devices		
• High-speed Photonic Networks	• High Performance Computing And Communications For Test And Evaluation, Simulation And Battle Management, Command Control And Communications (BM/C^3)	• National Information Infrastructure (NII)
• Terabyte Optical Storage	• Archival Storage For Test Data	• Large Public Databases, Digital Libraries, Medical, Commercial Video, And Other Archival Storage Media
Electronic Devices		
• Nonvolatile Semiconductor Random Access Memory (RAM)	• Long Life Memory For Theater Operations	• Wireless Communications Smart Highways
• Low Temperature (10 degrees Kelvin) Digital And Analog Superconducting Circuits	• Transceivers For Broadband Wireless Backbones For Telecommunications, High-speed Switching For Command And Control Centers (e.g., MMIC)	• Multimedia Centers
Computers		
• WASP 3-D Wafer Scale "Associative String" Reconfigurable Processor	• Graphics Engine For BM/C^3 And Test And Evaluation Workstation	• Visualization Engine For Multimedia
• 3-D Analog Neural Network Processor 3-DANN	• Compact (1 cubic inch) Low Power (1W) Fast Frame Seeker	• Powerful Neural Network Processor For Real-time Image Processing And Robotics Computation
• VIGILANTE - Sensor / Processor	• Investigates Real-time Detecting Tracking And Discrimination	• Teraflop Performance For Target Discrimination, Industry Feature Recognition
Communications		
• Laser Communications (LaserCom) 1 Gbps Transceiver	• High Capacity Jam-less Backbone For Sensor-to-Sensor Satellite Downlinks	• All Communication From Space And Between Satellites
• Miniaturized EHF Transceiver	• Wireless Communications Links For BM/C^3 And Test And Evaluation	• International Teleconferencing
Materials		
• Wide Bandgap Semiconductors	• Demonstrated True Blue Laser Diode, SiC Nonvolatile Random Access Memories Designed GaN Microwave Amplifier	• Thin Screen Color Display, Permanent Memory At RAM Access Speeds, Reduced Weight And Volume For Ground Based Radar Power Supplies
• Multifunctional Structures	• Integrates Power Distribution, Electronics, And Damping With Structural Members To Reduce Weight And Volume	• Satellite/Interceptor Systems
• Successful Flight Of STRV-1 U.S. / U.K. Microsatellites	• Improved Sensor Performance Due To Reduced Noise	• DoD, NASA Applications For Low Mechanical Noise Platforms
Rocket Propulsion		
• Energetic Oxetane Thermoplastic Elastomers	• Propellant Manufacturing Defects Corrected By Reheating And Recasting, Waste And Reclaimed Propellant Reused Without Penalty	• Tri-Service Interest Building, Integral Part Of Several IR&D Programs
• High-G Solid Divert And Altitude Control Propulsion	• Navy Safe Propulsion For Hit-to-Kill Interceptor Systems	• Highly Maneuverable Missile Systems Inside Or Outside Atmosphere
• Flexseal Vectorable Nozzle	• Reduces Cost, Enhances Interceptor Hit-to-Kill Performance	• Thrust Vector Control For Commercial Launch Systems
Miniature Interceptor Technology		
• Small, Accurate IMUs, Miniature Sensor Set Testing, Miniature Propulsion	• Address Ballistic Missile Submunition Threat	• Addresses Tactical Missile Threat, Miniature IMUs Offer Low Cost Alternative To Civilian GPS Receiver
Power And Propulsion		
• RHETT Hall Electric Thruster	• Orbit Insertion, Faster Orbital Repositioning	• Orbit Insertion, Station Keeping For Satellites, Cooperative Program With Navy
• Solar Array Technology That Includes Concentrators And Dual Bandgap Photovoltaic Materials	• 40% Reduction In Mass, 60% Reduction In Cost, Resistant To Van Allen Radiation	• Cooperative Program With NASA Flight Demonstration Tests Being Augmented By Communication Satellite Companies

cessfully tracked and collected data on four aircraft missions and several Resident Space Objects (RSOs), including the space shuttle. Throughout 1996, the MSX program transferred lessons-learned and technology information to the SBIRS community.

In the Directed Energy program, a high-power reactivation test of the Alpha laser device was successfully completed in September 1996 after being placed in an inactive/maintenance-only mode for over two years.

In ALI, all major assemblies were fabricated, integrated, and tested in the test chamber. In December 1996 an Alpha hot flow test was conducted while performing a low-power integration check-out of the ALI beam train. In compliance with Congressional language, design activities for the follow-on space qualified vehicle ground demonstration were restarted, and the Cost Analysis Requirements Document (CARD) was updated with emphasis in the CONOPS, user design requirements, satellite design, and launch vehicle design. Design reviews for the demonstrator space vehicle and operational SBL system concepts occurred in December 1996. The SBLRD test facility site selection process was restarted. The facility design, site selection, and preliminary environmental assessment for the Space Test Facility will be completed in FY 1997. Design activity for the SBLRD is continuing.

The Russian cooperative technology programs have been progressing. In August 1996, the Russian Government agreed to continue the Russian-American Observation Satellite (RAMOS) program. The Russian Space Industrial Company, NPO *Cometa*, under the auspices of *Rosvoorzhenie*, the Russians Arms Import/Export Agency, agreed to a number of satellite stereo viewing observations. In addition, several innovative aircraft and space sensor projects will be explored with Russia. In the Active Geophysical Rocket Experiment (AGRE), beacons for the U.S. MSX satellite were integrated onboard two Russian MR-12 sounding rockets, and were launched in January-February 1997 out of the Kapustin Yar range. MSX will observe the launches and high-altitude plasma cloud generated by the Russian's experimental payload.

In the AIT program, cooled window and forebody aero-optical shock tunnel tests were conducted, as well as forebody and airframe vibration tests and field joint validation.

Chapter 5

Program Funding

Chapter 5
Program Funding

5.1 Funding Summary

BMDO submitted the FY 1998 President's Budget in accordance with the Congressional instructions set forth in the FY 1997 National Defense Authorization Act. This report reflects several changes that occurred in FY 1997 and are proposed for FY 1998. First, NMD became a deployment readiness program. Consequently, NMD deployment readiness projects were organized and funded in the 2400 series. Second, the Department of Defense implemented several decisions that affected BMDO funding, including adjustments to the THAAD, Navy Theater Wide, and SBIRS programs. Another decision transferred BMDO procurement funding to the Services. Beginning in FY 1997, management support costs are allocated to specific BMD projects.

A composite funding perspective, combining all project funding, has also been provided as part of the budget justification materials. Figure 5-1 summarizes the total program funding by Program Element (PE). Figure 5-2 lists the current projects and provides a funding summary by project. Appendix B provides a narrative description of the activities planned, recent accomplishments, and funding plans for each project. The Congressional Descriptive Summaries (CDS) provided in support of the FY 1998 President's Budget request describe this information in greater detail.

Figure 5-1. Program Element Summary
(In Millions Of Then Year Dollars - Rounded)

Project Number And Title		FY 1997 Request	FY 1997 Appropriated	FY 1997 Current Estimate	FY 1998 Request	FY 1999 Programmed
PE 0603861C / 0604861C						
THAAD System						
2260 THAAD	RDT&E	482	622	619	556	595
	MILCON	0	0	0	5	0
	Total	482	622	619	561	595
PE 0208863C						
HAWK						
2358 HAWK System BM/C^3						
	Proc	19	19	15	0	0
	Total	19	19	15	0	0
PE 02028865C / 0604865C						
PATRIOT Advanced Capability-3 Missile						
2257 PATRIOT	RDT&E	382	382	381	206	101
	Proc	215	215	219	351*	372*
	Total	597	597	600	206	101
PE 0208867C / 0603867C / 0604867C						
Navy Area Missile Defense						
2263 Sea Based Area Defense						
	RDT&E	302	302	301	268	227
	Proc	9	9	9	15*	45*
	Total	311	311	310	268	227
PE 0603868C						
Navy Theater Wide Missile Defense						
1266 Sea Based Theater Wide						
	RDT&E	58	304	304	195	192
	Total	58	304	304	195	192
PE 0603869C						
Corps Surface-to-Air Missile						
2262 MEADS (Formerly Corps SAM)						
	RDT&E	56	56	56	48	10
	Total	56	56	56	48	10
PE 0603870C						
1292 UAV BPI						
	RDT&E	**	24	23	13	0
	Total		24	23	13	0

* Procurement Funding Transferred To The Services. Not Included In Total PE or BMDO Funding.
** Funds Requested Under PE 0603872C

Figure 5-1. Program Element Summary (Cont'd)
(In Millions Of Then Year Dollars - Rounded)

Project Number And Title	FY 1997 Request	FY 1997 Appropriated	FY 1997 Current Estimate	FY 1998 Request	FY 1999 Programmed
PE 0603872C / 0208864C					
Joint TMD Activities (RDT&E Except As Noted)	***				
1155 Phenomenology			31	38	39
1161 Advanced Sensor Technology			3	3	3
1170 TMD Risk Reduction			23	35	25
1294 UAV / BPI			1	0	0
2160 TMD Existing System Mods			22	12	13
2259 Israeli Cooperative Projects			44	39	39
3153 Architecture Analyses / BM/C^3 Initiatives			7	8	8
3157 Environment, Siting And Facilities					
RDT&E			6	4	3
MILCON			1	2	2
3160 TMD Readiness			2	2	2
3251 Systems Engr And Tech Supp			51	65	62
3261 BM/C^3I Concepts					
RDT&E			32	34	36
Procurement			20	20*	26*
3265 User Interface			14	15	22
3270 Threat And Countermeasures			21	28	29
3352 Modeling And Simulations			64	73	73
3354 Targets Support			23	28	19
3359 System Test And Evaluation			43	40	26
3360 Test Resources			36	31	30
4000 Operational Support			83	87	85
Subtotal RDT&E	520	526	506	542	514
Subtotal MILCON	1	1	1	2	2
Subtotal Procurement	20	20	20	20*	26*
Total	541 (Includes MILCON & BM/C^3I)	546 (Includes MILCON & BM/C^3I)	527	544	516
PE 0603871C					
2400 National Missile Defense	****	****			
Subtotal RDT&E	508	833	829	504	393
Subtotal MILCON	0	0	0	1	13
Total	508	833	829	505	406

* Procurement Funding Transferred to the Services. Not Included In Total PE or BMDO Funding.
*** Redefined Project Structure
**** During FY 1997, NMD Became A Deployment Readiness Program Consisting Of The 2400 Series Projects Previously Encompassed By 1151, 1155, 1267, 1460, 3152, 3153, 3157, 3160, 3265, 3270,3352, 3359, 3360, And 4000

Figure 5-1. Program Element Summary (Cont'd) (In Millions Of Then Year Dollars - Rounded)					
Project Number And Title	**FY 1997 Request**	**FY 1997 Appropriated**	**FY 1997 Current Estimate**	**FY 1998 Request**	**FY 1999 Programmed**
PE 0602173C / 0603173C					
Support Technologies (RDT&E)	***	***			
1155 Phenomenology			18	27	26
1161 Advanced Sensor Technology			33	24	23
1270 Advanced Interceptor Materials And Systems Technology			68	31	29
1360 Directed Energy Programs			96	29	28
1651 IS&T			58	51	50
1660 Statutory And Mandated Programs			52	55	50
3352 Modeling And Simulation			2	2	2
4000 Management Support			27	30	32
Total	226	366	354	249	240
Subtotal BMDO Funding	2,798	3,653	3,637	2,589	2,287
Subtotal BMDO-Related Procurement	0	0	0	386	443
Total BMDO-Related Funding	2,798	3,653	3,637	2,975	2,730
*** Redefined Project Structure					

Figure 5-2. Current Project Funding Profile (In Millions Of Then Year Dollars)

Project Number And Title		Funds Through FY 1996	FY 1997 Current Estimate	FY 1998 Request	FY 1999 Programmed
1155	Phenomenology	223	69	79	78
1161	Advanced Sensor Technology	145	36	27	26
1170	TMD Risk Reduction	80	23	35	25
1262	MEADS	95	56	48	10
1266	Navy Theater Wide Defense	356	304	195	192
1270	Advanced Interceptor Materials And Systems Technologies	64	68	31	29
1294	UAV BPI	6*	24	13	0
1360	Directed Energy Programs	192	96	29	29
1651	Innovative Science And Technology	818	58	51	50
1660	Statutory And Mandated Programs	390	52	55	50
2160	TMD Existing System Modifications	56	22	12	13
2257	PATRIOT (Includes Risk Reduction)	2,604	600	206	101
2259	Israeli Cooperative Projects	284	44	39	39
2260	THAAD	2,457	619	561	595
2263	Navy Area Defense	663	310	268	227
2358	HAWK System BM/C^3	98	15	0	0
2400	National Missile Defense (Includes NMD MILCON)	1,682**	829	505	406

* New Project For FY 1996
** During FY 1997, NMD Became A Deployment Readiness Program. Includes Funds From NMD Technology Readiness Program

Figure 5-2. Current Project Funding Profile (Cont'd)
(In Millions Of Then Year Dollars)

Project Number And Title		Funds Through FY 1996	FY 1997 Current Estimate	FY 1998 Request	FY 1999 Programmed
3153	Architecture Analysis / BM/C^{3}I Initiatives	36	9	11	11
3157	Environment, Siting and Facilities	48	7	6	5
3160	TMD Readiness	22	2	2	2
3251	Systems Engineering And Technical Support	128	51	65	62
3261	TMD BM/C^{3}I (BM/C^{3}I Concepts)	120	52	34	36
3265	User Interface	50	14	15	22
3270	Threat And Countermeasures Program	88	29	29	30
3352	Modeling And Simulations	285	99	97	97
3354	Targets Resources	173	23	28	19
3359	System Test And Evaluation	124	43	40	26
3360	Test Resources	124	47	42	41
4000	Operational Support	2,453	143	149	149
	Total:	13,864	3,637	2,589	2,287